HEAT PUMP WITH SECONDARY LOOP AIR-CONDITIONING SYSTEM

RELATED APPLICATION

[0001] This application claims all of the benefits of provisional application 60/487,460 filed July 15, 2003.

FIELD OF THE INVENTION

[0002] The subject invention relates to a heating and air-conditioning system for an automotive vehicle.

BACKGROUND OF THE INVENTION

[0003] In the normal system, in the heat pump mode, the refrigerant flow would be reversed so as to make the condenser, in effect, the evaporator and the evaporator the condenser. Thus, the heat that the evaporator gains from the ambient air will then be pumped into the condenser, which would be in the passenger compartment and thus provide heat. In the secondary loop system, the condenser is the chiller and the front-end heat exchanger is the evaporator (the passenger compartment heat exchanger will be called the cabin heat exchanger). The problem with both these systems is that the front-end heat exchanger cools down the ambient air, which may already be very low in temperature (below 40^0F). This causes this heat exchanger to freeze. This results in inadequate performance and potentially no performance after a while. A way around this is to utilize the heat from the coolant to evaporate the refrigerant in the evaporator. In such a system the front-end heat exchanger is bypassed and is replaced by a refrigerant-to-glycol (RTG) heat

exchanger. This allows the coolant, which is warming up to be the source of heat for the evaporation process in the RTG. This, of course, slows down the coolant warm-up rate but is insignificant and results in dumping heat into the passenger compartment with a significantly higher rate because of the compression process.

SUMMARY OF THE INVENTION AND ADVANTAGES

[0004] The subject invention utilizes the secondary loop concept in conjunction with a heat pump.

[0005] A heater and air-conditioning assembly for a vehicle comprising a compressor for compressing a refrigerant and a front-end condenser for condensing fluid from the compressor. A chiller-condenser is disposed downstream of the condenser and a chiller-evaporator is disposed downstream of the chiller-condenser. A main three-way valve is disposed between the compressor and the condenser for directing flow from the compressor to the condenser in an air-conditioning mode and for directing flow from the compressor through a by-pass line to the chiller-condenser in a heat pump mode. A heat pump expansion device exchanges heat with the refrigerant in the heat pump mode and a by-pass valve is disposed between the chiller-condenser and the chiller-evaporator for directing flow from the chiller-condenser through the heat pump expansion device and to the chiller-evaporator in the heat pump mode.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Other advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following

detailed description when considered in connection with the accompanying drawings wherein:

[0007] Figure 1 is a schematic view illustrating the air-conditioning mode, and

[0008] .Figure 2 is a schematic view illustrating the heat pump mode.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0009] Referring to the drawings, a heater and air-conditioning assembly for a vehicle is shown schematically in Figures 1 and 2 wherein Figure 1 illustrates the normal air-conditioning mode and Figure 2 illustrates the heat pump mode.

[0010] As is customary, the system includes a compressor **12** for compressing a refrigerant and a front-end heat exchanger that acts as the traditional condenser **14** for condensing fluid from the compressor **12** in the air-conditioning mode.

[0011] A chiller-condenser **16** is disposed downstream of the condenser **14** and a chiller-evaporator **18** is disposed downstream of the chiller-condenser **16**. A main three-way valve **20** is disposed between the compressor **12** and the condenser **14** for directing flow from the compressor **12** to the condenser **14** in the air-conditioning mode and for directing flow from the compressor **12** through a by-pass line **22** to the chiller-condenser **16** in the heat pump mode.

[0012] A heat pump (HP) expansion device **24**, taking the form of an orifice tube, is disposed between the chiller-condenser **16** and the chiller-evaporator **18** for expanding the refrigerant in the heat pump mode and a by-pass valve **26** is disposed between the chiller-condenser **16** and the chiller-evaporator **18** for directing

flow from the chiller-condenser **16** through the heat pump expansion device **24** and to the chiller-evaporator **18** in the heat pump mode. For clarity the chiller-condenser **16** and chiller-evaporator **18** are shown separately in the figures, in reality they will be combined in one integral unit containing by-pass valve **26,** expansion device **24** and interconnect **40** inserted between the appropriate tube passes.

[0013] An air-conditioning (A/C) expansion device **28**, taking the form of an orifice tube, is disposed downstream of the condenser **14** and upstream of the by-pass line **22** for expanding the refrigerant adiabatically in the air-conditioning mode.

[0014] As is customary, a return line **30** extends from the chiller-evaporator **18** to the compressor **12** and an accumulator-dehydrator **32** is disposed in the return line **30**.

[0015] A coolant feed line **34** conducts coolant flow from the chiller-condenser **16** to a cabin heat exchanger **36** while a coolant exit line **38** conducts coolant from the cabin heat exchanger **36** to the chiller-evaporator **18**. An interconnect line **40** conducts coolant from the chiller-evaporator **18** to the chiller-condenser **16**. Line **40** shown in the figures for clarity. In actual practice line **40** will be internally incorporated in the coolant circuit (or pass) going from the chiller-evaporator **18** to the chiller condenser **16**. A circuit pump **42** is disposed in the feed line for pumping coolant from the chiller-condenser **16** to the cabin heat exchanger **36**. A coolant three–way valve **44** is disposed in the exit line **38** for directing coolant from the cabin heat exchanger **36** to the engine coolant circuit in the heat pump mode. The customary heater **46** is disposed in the coolant circuit along with an engine pump (EP) **48** in the coolant circuit for pumping coolant through an engine **50** and the heater **46**.

[0016] The system includes an engine radiator **52** and a thermostat **54** in the coolant circuit for selectively directing coolant in the coolant circuit through the heater **46**, and/or the radiator **52** and/or the chiller-evaporator **18**.

[0017] In the present invention, as shown in Figure 2, the refrigerant flows through the main three-way valve **20** to bypass the traditional condenser **14** in the air-conditioning system. The refrigerant flows through a chiller-condenser **16** portion of a heat exchanger, which is generally or totally called the chiller in the air-conditioning mode (as shown in Figure 1). Reverting back to Figure 2, this chiller-condenser **16** portion of the heat exchanger acts as a condenser in the heat pump mode. In this heat exchanger, the refrigerant rejects heat to the coolant warming it up significantly. The coolant then flows through the cabin heat exchanger **36** warming up the air flowing across it into the passenger compartment. As shown in Figure 2, there is a bypass valve **26** within the chiller heat exchanger allowing the refrigerant to flow through the HP orifice tube **24** in the heat pump mode. In the air-conditioning mode the HP orifice tube **24** is bypassed as shown in Figure 1. This geometry allows the use of two expansion devices **24** and **28** shown as orifice tubes in the system; **24** operational in the heat pump mode and **28** operational in the air-conditioning mode. This is a significant advantage because this allows optimization of size for the two modes independently and inexpensively.

[0018] Again, reverting back to Figure 2, after the refrigerant flows through the HP orifice tube **24** it goes into the chiller-evaporator **18** that takes heat away from the coolant in allowing the refrigerant to evaporate. This, of course, cools down the coolant but the net gain in heat is insignificant because of the pumping action of the compressor. Thus, the condenser **14** is not utilized in the heat pump

mode. Again, this eliminates the freezing of the moisture on the "evaporator" in the heating mode.

[0019] Regarding the coolant circuit, the coolant three-way valve **44** directs the coolant through the engine **50** and prevents coolant from bypassing the engine **50**. The coolant flows through the traditional heater core **46** and/or the cabin heat exchanger **36** and/or through the radiator **52**, or all three circuits. The flow path is determined by the thermostat **54**, which is controlled electronically. This allows the flow through the heater core **46** to be cut off completely when the air-conditioning is on helping in air-conditioning discharge temperatures because of the absence of heat in the HVAC module (generally the flow of hot coolant in the heater core **46** raises a/c discharge temperatures by 1 – to 2^0F). Of course, in winter, when heat is required in the passenger compartment, cold coolant is initially routed only through the cabin heat exchanger **36** circuit. This is because the cold coolant does not help in warm-up by passing it through the heater core **46**. When a sufficiently high temperature is reached, the coolant is also partially circuited into the heater core **46** and subsequently to the radiator **52**. When the coolant is warm enough to be cooled in the radiator **52**, the heat pump is turned off.

[0020] Also, the cabin heat exchanger circuit has an electrically driven pump. This pump is sized to allow pumping of a more viscous coolant in air-conditioning mode. The coolant is fairly cold during this operation because it is cooled down to 20-30^0F to allow for good air-conditioning performance that makes the coolant viscous.

[0021] As illustrated in Figure 1, switching the 3-way valve **20** into the correct or normal A/C position now uses the main condenser circuit. This circuit also includes the A/C orifice tube **28** that is used for air-conditioning. As mentioned

earlier, this A/C orifice tube **28** is sized correctly for air-conditioning mode. The HP orifice tube **24** within the two chiller portions is bypassed in the A/C mode resulting in one big chiller **16, 18**. This is a very big advantage because the chiller is sized for air-conditioning performance and results in too big of a heat exchanger for the heat pump mode. Thus, the two split heat exchangers or chillers **16** and **18** in heat pump mode are more optimally sized for heat pump performance.

[0022] In the air-conditioning the coolant is restricted to the cabin heat exchanger **36** circuit. The three-way valve **44** located ahead of the engine water pump **48** directs coolant into the coolant line **38** cutting off flow to the engine **50**. Also, the thermostat **54** at the engine shuts off flow to the cabin heat exchanger circuit; a bleed into this circuit from the engine would be detrimental to A/C performance.

[0023] During times of a real need to cool down the engine **50** beyond the capability of the radiator **52**, e.g., in a hill climb, the coolant could be routed through the engine **50** to cool it down. Of course, this would result in a loss of air-conditioning in the passenger compartment during this time but this would result in additional engine cooling in an emergency.

[0024] In another embodiment, the heater core **46** may be eliminated. As can be noted in Figure 2, the coolant would then be pumped through the engine **50**, by the engine pump **48**, then through the chiller-evaporator **18** and chiller-condenser **16**, then through the cabin heat exchanger **36** and the coolant 3-way valve **44** and then back through the engine. This saves the cost of another heat exchanger. When the coolant temperature reaches a sufficiently high temperature the heat pump can be turned off. Incidentally, the electric pump can be turned off for most heat pump applications and is necessary mainly for air-conditioning operation.

[0025] Obviously, many modifications and variations of the present invention are possible in light of the above teachings. The invention may be practiced otherwise than as specifically described within the scope of the appended claims.